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ELEVATION EFFECTS ON RAINFALL NEAR HOLLIS, ALASKA

by
W. J. Walkotten, Forestry Research Technician[1]
and
J. H. Patric, Research Hydrologist[1]

INTRODUCTION

Most precipitation measurements in southeast Alaska are obtained near sea level. Although precipitation on this mountainous coastal region is known to increase with elevation (Federal Power Commission and U.S. Forest Service 1947), few measurements have been made on the densely forested, nearly inaccessible mountains. For a comparison of mountainside rainfall with that at sea level, measurements were made in the fall of 1965 during frequent visits to soil stability plots on a logged mountainside.

STUDY SITE

The Hollis study site (45 miles west of Ketchikan, Alaska) was clearcut in patches during 1957-60. It was on a steep (22.5°), uniform slope facing east-southeast, into the prevailing storm direction. A logging road permitted ready access over the elevational range of the study site (fig. 1). The unlogged, old-growth forest was predominately western hemlock and included Sitka spruce, Alaska-cedar, and western redcedar. The clearcut, low-brush area contained a well-stocked seedling stand of these tree species with salmonberry and huckleberry.

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[1] Stationed at Institute of Northern Forestry, Juneau, Alaska.

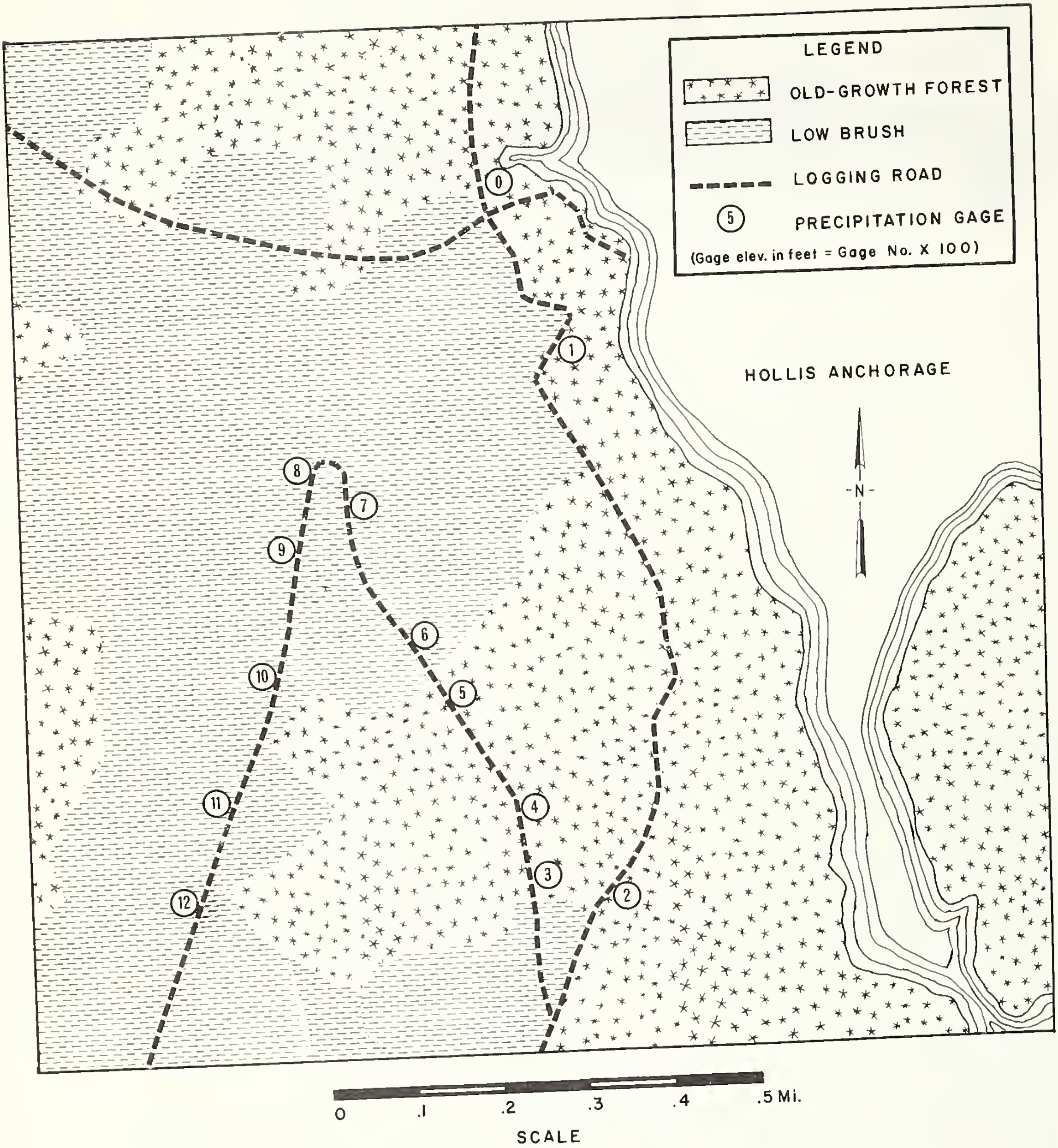

Figure 1.--*The study area. The abandoned mining town of Hollis is just below precipitation gage 1.*

METHOD

Number 10 food cans were used for rain gages, except at sea level where a standard 8-inch U.S. Weather Bureau gage was installed with a number 10 can gage nearby. This pair provided a check on the performance of the can gages. Single can gages were placed along the logging road at 100-foot-elevation intervals to 1,200-foot elevation (fig. 1). Stations 0 through 5 were in old-growth forest, 6 through 12 were in low brush. Wind was noticeably stronger at gage stations in low brush, but windspeed was not measured and gages were unshielded. Rain amounts were recorded on a per-storm basis. A storm was defined as a period of essentially continuous rain separated from other stormy periods by at least 6 hours without rain. Two storm records were discarded when snow fell at elevations above 800 feet. Standard-gage catch was measured directly in inches with a graduated stick. Can-gage catch was measured in cubic centimeters in a graduated cylinder and later converted to inches depth.

RESULTS

Records were obtained from 21 storms ranging in size from 0.04 to 2.66 inches at sea level (table 1). A total of 22.44 inches of rain was measured at sea level during the period of record. The similarity of catch between the standard gage and can gage at station 0, or at sea level, confirms Ursic and Thames' (1958) claim that number 10 cans are satisfactory for many rain-gaging purposes. Can-gage catches were grouped as shown by letter designations in table 1 to provide replicated sampling within selected elevational ranges.

Plotting gage catch by elevation intervals for various storm sizes showed considerable similarity among storms with less than 1.5 inches of rainfall and greater than 1.5 inches. For this reason, average gage catch was plotted for all storms by size classes and elevations, as shown in figure 2. Both elevation and wind influences are apparent in this figure. Gages from sea level to 500 feet were within old-growth forest, and curves for storms less than 1.5 inches and storms greater than 1.5 inches indicate gage catch increasing by 0.01 and 0.04 inch per 100 feet of elevation, respectively. Gages from 600 to 1,100 feet were exposed in low brush, but their catch nevertheless increased at the same rate as gages in old-growth forest. The offset at the old-growth forest—low brush juncture is wind effect, which uniformly reduced catch in all gages exposed in low brush but had no influence on the rate at which gage catch increased with elevation. For all storms, Table 1.--Rainfall measurements at 100-foot-elevation intervals at Hollis, Alaska, 1965, by storm size and date

Station No.[1]	Elevation group[2]	Storms up to 1.5 inches															Storms greater than 1.5 inches					
		9/28	9/30	10/1	10/3	10/4	10/8	10/9	10/12	10/21	10/23	10/25	10/28	10/30	11/2	11/4	10/6	10/11	10/14	10/17	10/20	10/22
		Inches															Inches					
STD[3]	A	0.04	0.46	0.61	1.22	1.17	0.99	0.20	0.37	0.32	0.78	0.19	1.13	1.28	1.14	0.62	2.66	2.21	1.85	1.70	1.54	1.96
0	B	.04	.50	.61	1.24	1.16	.97	.16	.34	.31	.77	.18	1.10	1.27	1.11	.58	2.71	2.19	1.84	1.71	1.59	1.99
1	B	.07	.54	.63	1.27	1.14	.99	.18	.43	.32	.77	.19	1.11	1.25	1.17	.62	2.72	2.26	1.86	1.74	1.61	1.99
2	B	--	--	.70	1.39	1.19	1.05	.19	.38	.35	.78	.19	1.13	1.26	1.23	.65	--	2.30	2.02	1.73	1.63	2.07
3	C	.06	.61	.70	1.49	1.23	1.03	.20	.38	.33	.76	.18	1.12	1.24	1.22	.65	2.74	2.41	2.09	1.79	1.70	2.15
4	C	.07	.63	.68	1.48	1.29	--	.19	.39	.33	.76	.19	1.09	1.24	1.18	.66	2.72	2.41	2.08	1.77	1.66	2.16
5	C	.09	.65	.69	1.50	1.26	1.06	.20	.44	.34	.79	.20	1.12	1.25	1.21	.66	2.87	2.48	2.08	1.81	1.72	2.21
6	D	.08	.59	.66	1.37	1.10	1.05	.20	.42	--	.79	.19	1.10	1.26	1.06	.61	2.79	2.31	1.83	1.86	1.62	2.10
7	D	.07	.60	.73	1.36	1.09	1.00	.22	.36	.33	.74	.19	.98	1.22	.99	.58	2.59	2.30	1.79	1.73	1.60	2.08
8	D	.08	.60	.64	1.41	1.12	1.07	.24	.35	.34	.87	.18	1.23	1.33	1.14	.56	3.10	2.36	1.89	1.99	1.53	2.06
9	D	.09	.62	.67	1.31	.97	1.05	.26	.36	.33	.80	.18	1.08	1.30	.95	.54	2.75	2.41	1.69	1.86	1.39	1.93
10	E	.12	.70	.71	1.61	1.18	1.06	.24	.36	.35	.86	.18	1.25	1.31	1.12	.57	3.11	2.45	1.98	1.96	1.60	2.14
11	E	.12	.74	.73	1.60	1.14	1.04	.26	.33	.34	.77	.18	1.11	1.22	1.06	.60	2.89	2.54	2.01	1.77	1.64	2.18
12	E	.13	.70	.72	1.60	1.03	1.07	.26	.33	.37	.79	.18	1.11	1.26	1.04	.62	2.95	2.44	1.99	1.87	1.52	2.01

[1] Gage elevation in feet = station number x 100.

[2] Elevation group refers to mean elevation:
A = sea level
B = 100 feet
C = 400 feet
D = 750 feet
E = 1,100 feet

[3] Standard rain gage--all other stations used a No. 10 can gage.

for each inch of rain at sea level, the average rainfall increase was 0.02 inch per 100 feet of elevation. This amounted to an average increase in rainfall of 2 percent per 100-foot rise in elevation.

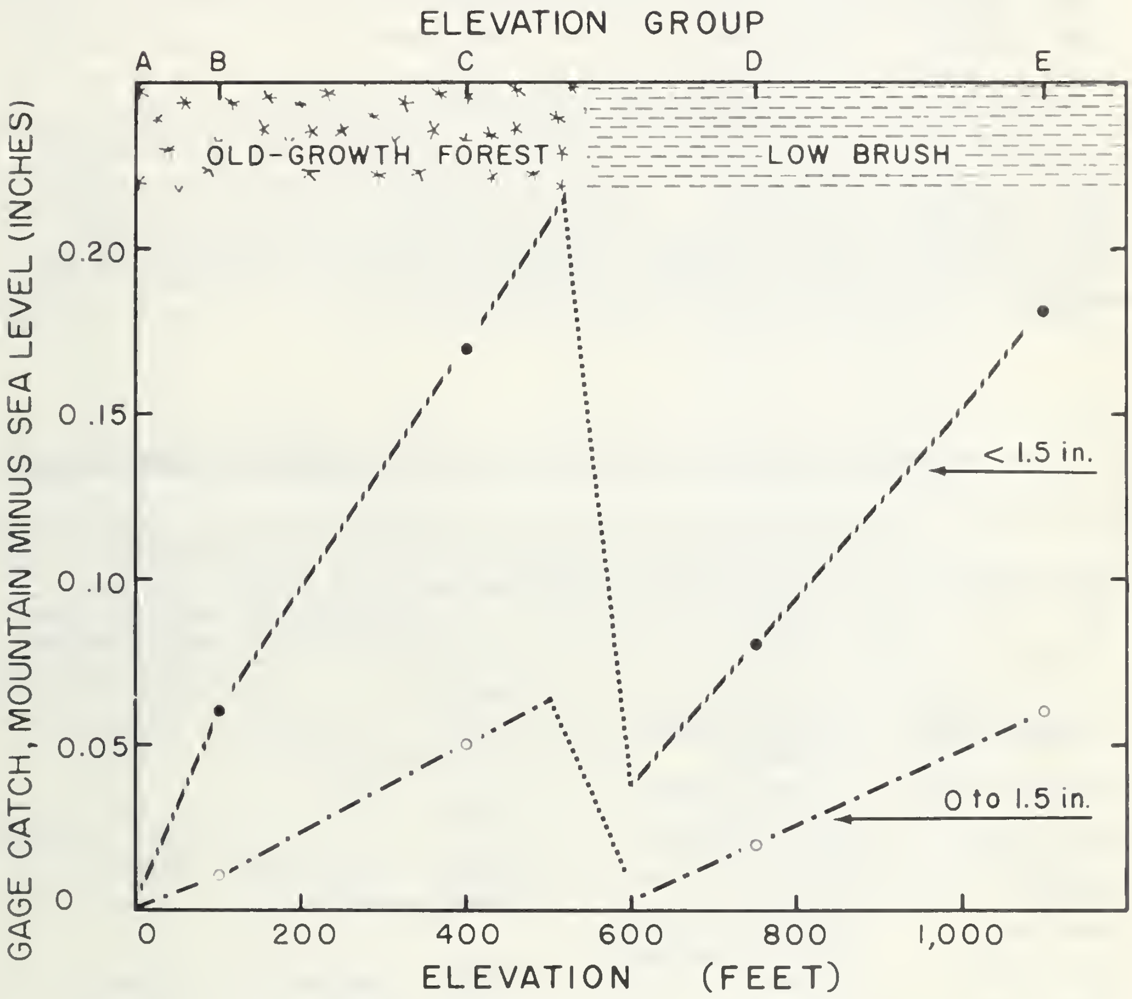

Figure 2.--*Influence of elevation and vegetation on rain gage catch at Hollis, Alaska.*

DISCUSSION

The results indicate that sea level rainfall sampling provides only minimum estimates of mountain rainfall at Hollis. The increase of 0.02 inch of rain per 100 feet of elevation does not, however, apply to other gage locations in the Hollis vicinity. Apparently, differing land configuration causes variation among individual elevation-rainfall relations. Nevertheless, our results agree fairly well with sea level versus mountainside comparisons from other locations along this sea coast (table 2). Kendrew and Kerr (1955) noted that precipitation differences between Britannia Beach and Britannia Mine were least during the summer. If summertime differences are small at Hollis, then our figure of 117 percent (table 2) may be small since our rainfall sampling was done in early autumn. It appears from scanning the Deer Mountain rainfall record that the winter ratio of sea level—mountainside rainfall is highest, but this seasonal difference is not apparent in data from the stations farther north.

Table 2.--Comparison of mountain with sea-level precipitation along the North Pacific coast

Station	Source of data	Elevation	Precipitation	
			Inches[1]	Percent of nearest sea-level station
		Feet		
Porcupine Creek	U.S. Weather Bureau, Anchorage	1,800	39.00	184
Kensington Mine	U.S. Weather Bureau, Anchorage	2,025	74.65	146
Mount Juneau	Murphy and Schamack (1966)	3,400	128.10	313
Hollis	This study	1,200	26.35	117
Deer Mountain	Unpublished data, U.S. Bureau of Reclamation, Juneau	2,600	240.39	122
Tunnel Camp	Kendrew and Kerr (1955)	2,200	95.6	126

[1] Precipitation amounts are for various lengths of time.

Do the offsets in figure 2 actually reflect decreased gage catch caused by more wind outside the forest? Wind data are unavailable for Hollis, but we noticed that it blew most of the time and hardest outside the forest. The nearest wind recorder was on Annette Island (U.S. Weather Bureau 1965), 50 miles southeast of Hollis and across Clarence Strait. Annette data showed that sea-level wind averaged 13.4 m.p.h. from the southeast. If we assume that wind at Hollis differed little from Annette and apply Fons' (1940) results, average windspeed inside the forest would not exceed 2 m.p.h. Foster (1948, p. 46) states that at 8.94 m.p.h. wind decreases rain-gage catch by 10 percent, winds of 13.41 m.p.h. by 19 percent. Thus, the assumed windspeed increase of 11 m.p.h. outside the forest was ample to decrease rain-gage catch by approximately 10 percent as shown in figure 2.

Table 2 suggests a fairly uniform regional pattern of topographic influence on rainfall. This pattern could be more closely defined on a larger study area having large elevation spans permitting adequate statistical treatment of the data. The need for further study of the influence of elevation on precipitation is apparent when stream gages frequently measure runoff from mountains exceeding sea level rainfall (Federal Power Commission and U.S. Forest Service 1947).

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